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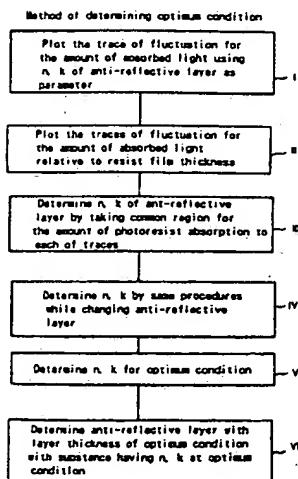
54 Method of determining optimum optical conditions for an anti-reflective layer used in a method of forming a resist pattern.

57 A method of determining an optimum condition of an anti-reflective layer upon forming a resist pattern by exposure with a monochromatic light, a method of forming the anti-reflective layer therewith, a method of forming a resist pattern using a novel anti-reflective layer obtained therewith, and a method of forming a film.

The optimum condition of the anti-reflective layer is determined and the anti-reflective layer is formed by the methods described below. Further, an optimal anti-reflective layer is obtained by the method which is used for forming the resist pattern. The method comprises (I) forming an equi-contour line for the amount of absorbed light regarding a photoresist of an optional film thickness using the optical condition of the anti-reflective layer as a parameter, (II) conducting the same procedure as in (I) above for a plurality of resist film thicknesses, (III) finding a common region for the amount of absorbed light with respect to each of the traces obtained, thereby determining the optical condition for the anti-reflective layer, (IV) applying same procedures as described above while changing the condition of the anti-reflective layer, thereby determining the optical condition

for the anti-reflective layer, and (V) determining the optimum optical condition such as the kind and the thickness of the anti-reflective layer under a certain condition of the anti-reflective layer.

FIG. 1





European Patent  
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# EUROPEAN SEARCH REPORT

Application Number  
EP 93 11 3219

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X	PROCEEDINGS OF THE SPIE - CONFERENCE OPTICAL/LASER MICROLITHOGRAPHY V, vol. 1674, 11 March 1992 - 13 March 1992 SAN JOSE, CA., USA, pages 362-375, TOHRU OGAWA ET AL. 'Novel ARC optimization methodology for KrF excimer laser lithography at low K1 factor' * abstract * * page 364, paragraph 2.3 - page 366, paragraph 2.4; figures 1,5-10 *	1,5,14	G03F7/09 H01L21/027
X	EP-A-0 098 582 (TOKYO SHIBAURA DENKI K.K.) * page 3, line 27 - page 4, line 1 * * page 4, line 29 - page 6, line 4; figures 3-5 * * page 6, line 31 - page 7, line 7; claims 1,2,7 *	11,12	
A		2,4,6,8,22	
X	EP-A-0 379 604 (SIEMENS AG.) * column 1, line 1 - line 43 * * column 2, line 31 - line 36 * * column 3, line 1 - line 9 * * column 4, line 6 - line 14; figure 3 * * column 4, line 21 - line 28 *	11,20	TECHNICAL FIELDS SEARCHED (Int.Cl.5) H01L G03F G02B
A		4,13	
X	US-A-4 451 969 (ARUP R. CHAUDHURI) * column 2, line 37 - line 47 * * column 4, line 25 - line 68; figure *	22	
A		4,11,12	
		-/--	
The present search report has been drawn up for all claims			
Place of search BERLIN		Date of completion of the search 10 May 1995	Examiner Klopfenstein, P
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

EPO FORM 1503 (01.81) (P04001)



DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X	THIN SOLID FILMS, vol. 164, 1988 pages 375-379, H. ZORC ET AL. 'Medium optical index material tailoring by plasma-enhanced chemical vapour deposition' * page 376, paragraph 2; table 1 *	33-35	
X	PATENT ABSTRACTS OF JAPAN vol. 14 no. 222 (E-0926) ,10 May 1990 & JP-A-02 055416 (SEIKO EPSON CORP.) 23 February 1990, * abstract *	33,34	
A	---	35	
X	JOURNAL OF APPLIED PHYSICS, vol. 62,no. 11, 1 December 1987 pages 4538-4544, Y CROS ET AL. 'Optical properties of plasma enhanced chemical vapor deposited silicon-oxynitride films' * page 4538, paragraph I * * page 4539, paragraph III; table I *	33,34	
A	---	35	TECHNICAL FIELDS SEARCHED (Int.Cl.5)
	---	-/--	
The present search report has been drawn up for all claims			

Place of search

BERLIN

Date of completion of the search

10 May 1995

Examiner

Klopfenstein, P

CATEGORY OF CITED DOCUMENTS

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A : technological background  
O : non-written disclosure  
P : intermediate document

T : theory or principle underlying the invention  
E : earlier patent document, but published on, or after the filing date  
D : document cited in the application  
L : document cited for other reasons  
-----  
& : member of the same patent family, corresponding document

EPO FORM 1503 01.92 (P0409)



DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. CL.5)
P,X	OPTICAL/LASER MICROLITHOGRAPHY, SAN JOSE, CA, USA, 3-5 MARCH 1993, vol. 1927, pt.1, ISSN 0277-786X, PROCEEDINGS OF THE SPIE - THE INTERNATIONAL SOCIETY FOR OPTICAL ENGINEERING, 1993, USA, pages 263-274, OGAWA T ET AL 'Practical resolution enhancement effect by new complete anti-reflective layer in KrF excimer laser lithography' * abstract * * page 264 - page 265; figures 1-5 * * page 266, paragraph 3.2 *	1,5,14, 22,33-35	
P,A		4,8-10, 13, 17-19, 23-32	
P,X	PROCEEDINGS OF THE SPIE - CONFERENCE OPTICAL/LASER MICROLITHOGRAPHY VI, vol. 1927, 3 March 1993 - 5 March 1993 SAN JOSE, CA. USA, pages 275-286, HAN J. DIJKSTRA ET AL. 'Optimization of Anti-Reflection layers for deep UV lithography' * page 278 - page 283; figures 2,3,5; tables 1,2 *	11,12, 20,21	TECHNICAL FIELDS SEARCHED (Int. CL.5)
P,A		1,4,9, 13,14, 18,23, 24,27,28	
The present search report has been drawn up for all claims			
Place of search BERLIN		Date of completion of the search 10 May 1995	Examiner Klopfenstein, P
<b>CATEGORY OF CITED DOCUMENTS</b> X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 01.81 (P04C01)



DOCUMENTS CONSIDERED TO BE RELEVANT			
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A	PROCEEDINGS OF THE SPIE - CONFERENCE OPTICAL/LASER MICROLITHOGRAPHY V, vol. 1674, 11 March 1992 - 13 March 1992 SAN JOSE, CA., USA, pages 350-361, Y. SUDA ET AL. 'A new anti-reflective layer for deep UV lithography' Abstract * page 352, paragraph 3 - page 353; figures 1, 8, 10, 11 *	1, 5, 14	
A	PATENT ABSTRACTS OF JAPAN vol. 15 no. 464 (E-1137), 25 November 1991 & JP-A-03 200367 (SANYO ELECTRIC CO LTD) 2 September 1991, * abstract *	4, 33, 34	
A	FR-A-1 534 173 (GENERAL PRECISION INC.) * page 1 - page 3; figure 2 *	2	
T	DE-A-43 11 761 (MITSUBISHI DENKI K.K.) 21 October 1993 * page 5, line 29 - page 6, line 15 *	4	TECHNICAL FIELDS SEARCHED (Int. Cl. 5)
The present search report has been drawn up for all claims			
Place of search BERLIN		Date of completion of the search 10 May 1995	Examiner Klopfenstein, P
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons * : member of the same patent family, corresponding document	

EPO FORM 1503 Q1.82 (P04C01)



### CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

- ☐ All claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for all claims.
- ☐ Only part of the claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claims:
- ☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

### ☒ LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirement of unity of invention and relates to several inventions or groups of inventions,

namely:

1. Claims 1,5,14: A method of determining the optimal optical conditions for an anti-reflective layer in a method of forming a resist pattern.
2. Claims 2,3,6,7,15,16: A method using a  $\text{SiO}_2$  anti-reflective layer with specific optical indexes.
3. Claims (4,8,13,17), (9,10,18,19), (11,12,20,21), (23,25), (24,26), (27,29,31), (28,30,32,34) (7 independent claims): A method using a  $\text{Si}_x\text{O}_y\text{N}_z$  or  $\text{Si}_x\text{N}_y$  anti-reflective layer characterized by specific optical indexes or underlying materials or compositional features.
4. Claim 22: A method using a silicon oxide or silicon nitride or silicon oxide nitride or silicon carbide anti-reflective layer containing hydrogen.
5. Claims 33-35: A method of forming a film by vapor phase deposition using a raw gas containing at least silicon and oxide elements.

- ☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.
- ☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:
- ☐ None of the further search fees has been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

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ALLAN S. JOHN ROBERTS  
EPILOG & MATKIN, P.S.

# Fig.68

Operation of Example 90

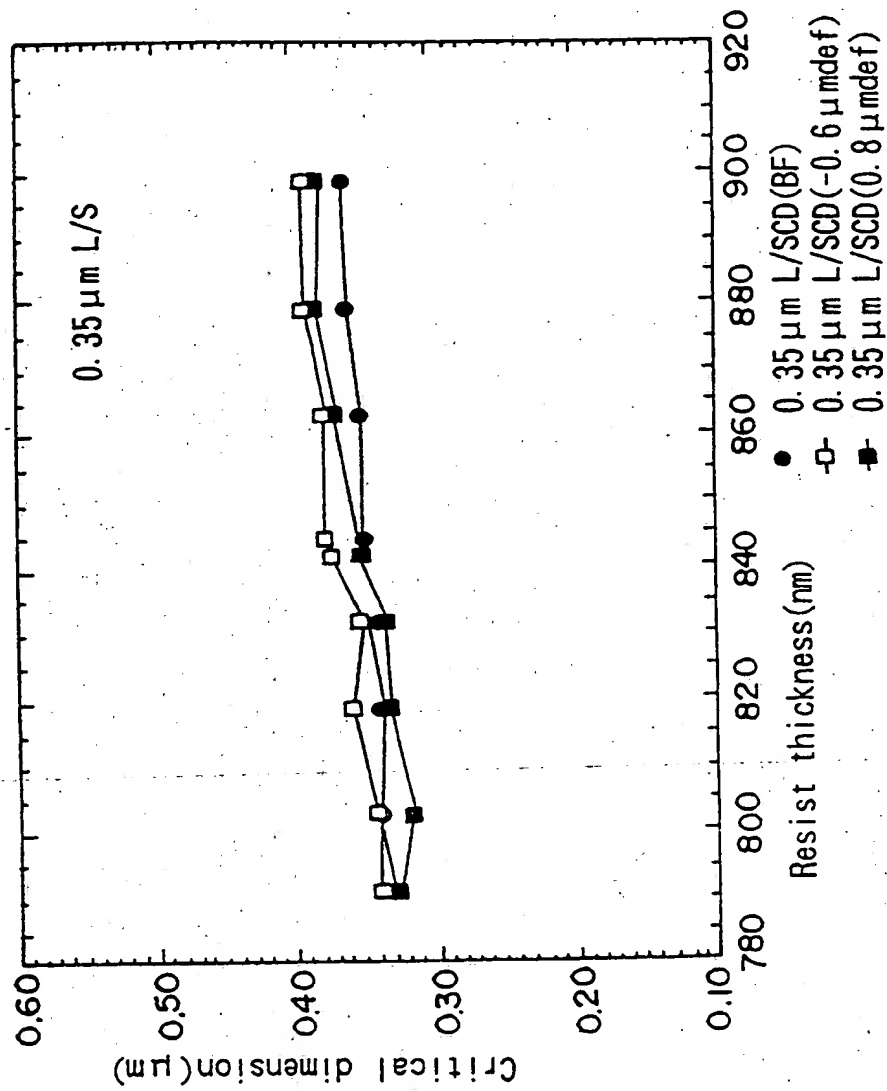
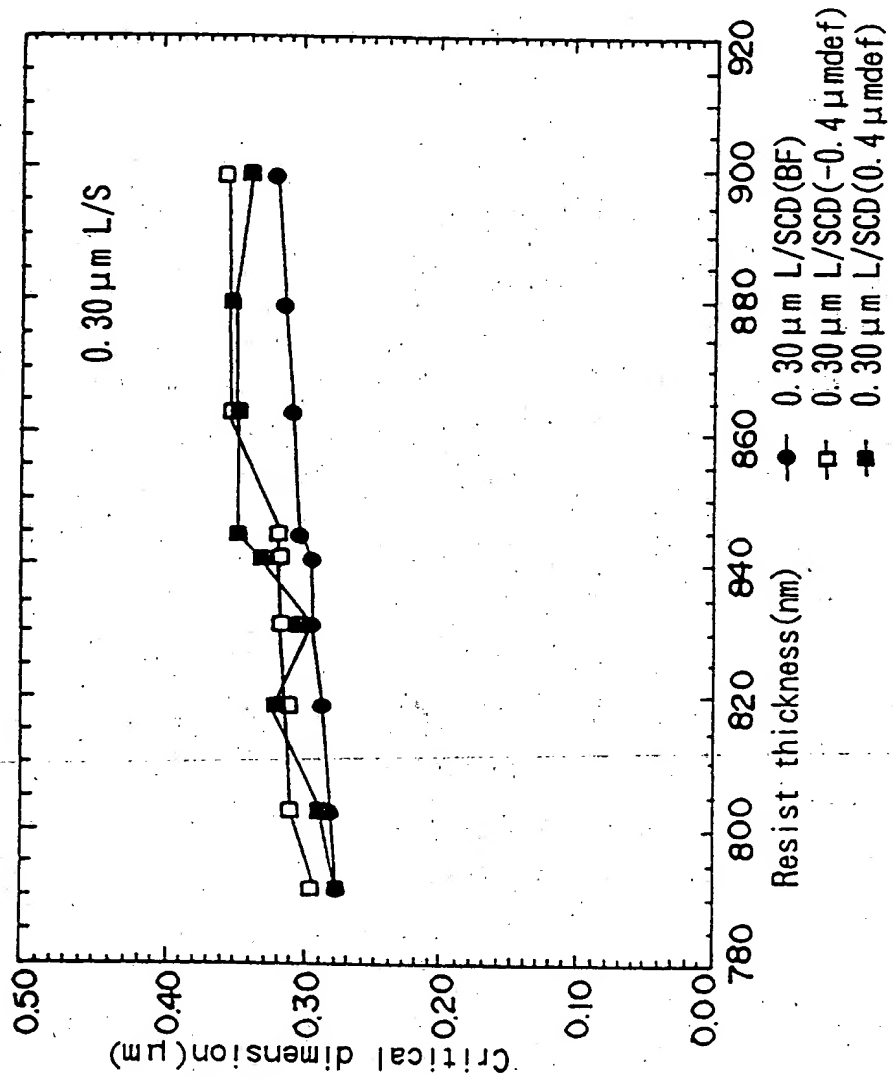


Fig.67

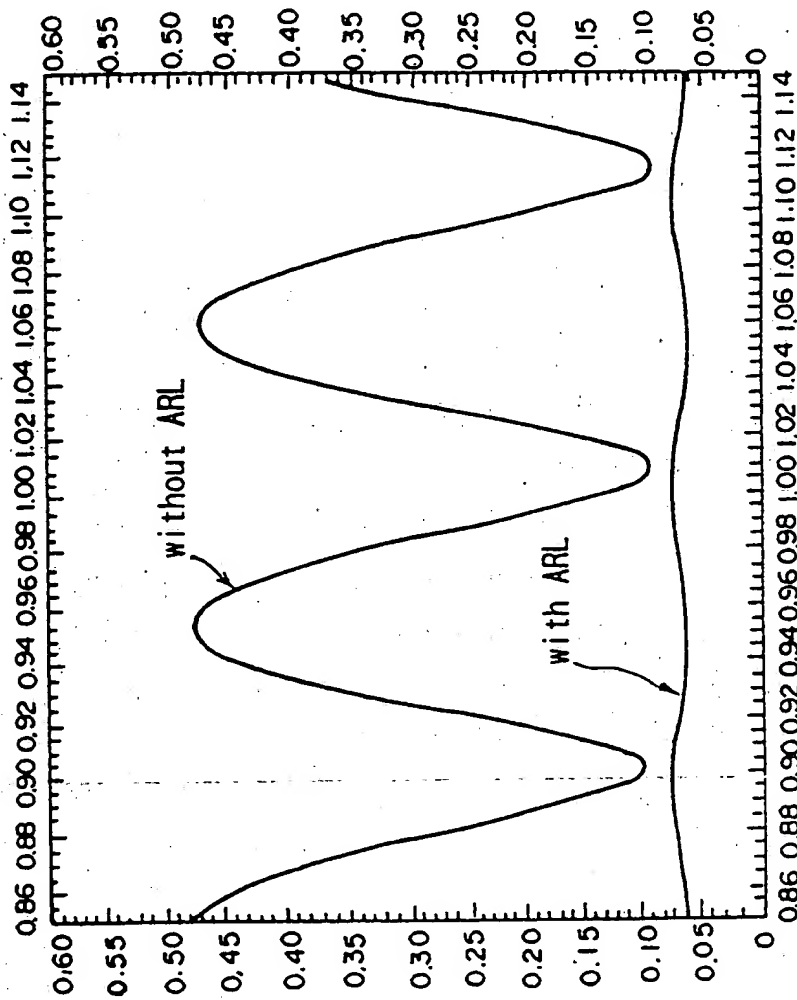
Operation of Example 90





# Fig.66

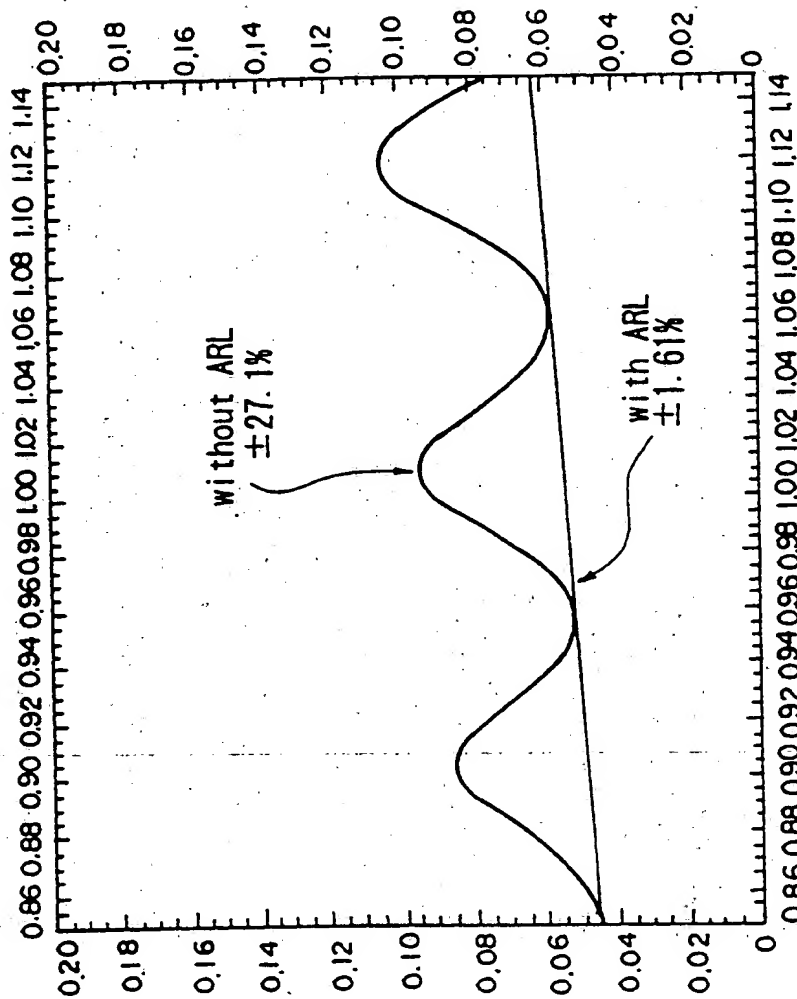
Anti-reflective effect of the film formed  
in Example 90 (reflective ratio)



Conditions: As same in Fig64

# Fig.65

Anti-reflective effect of the film formed  
in Example 90 (absorption ratio)



Conditions:  $n_{\text{airi}}=2.58$

$k_{\text{airi}}=0.42$

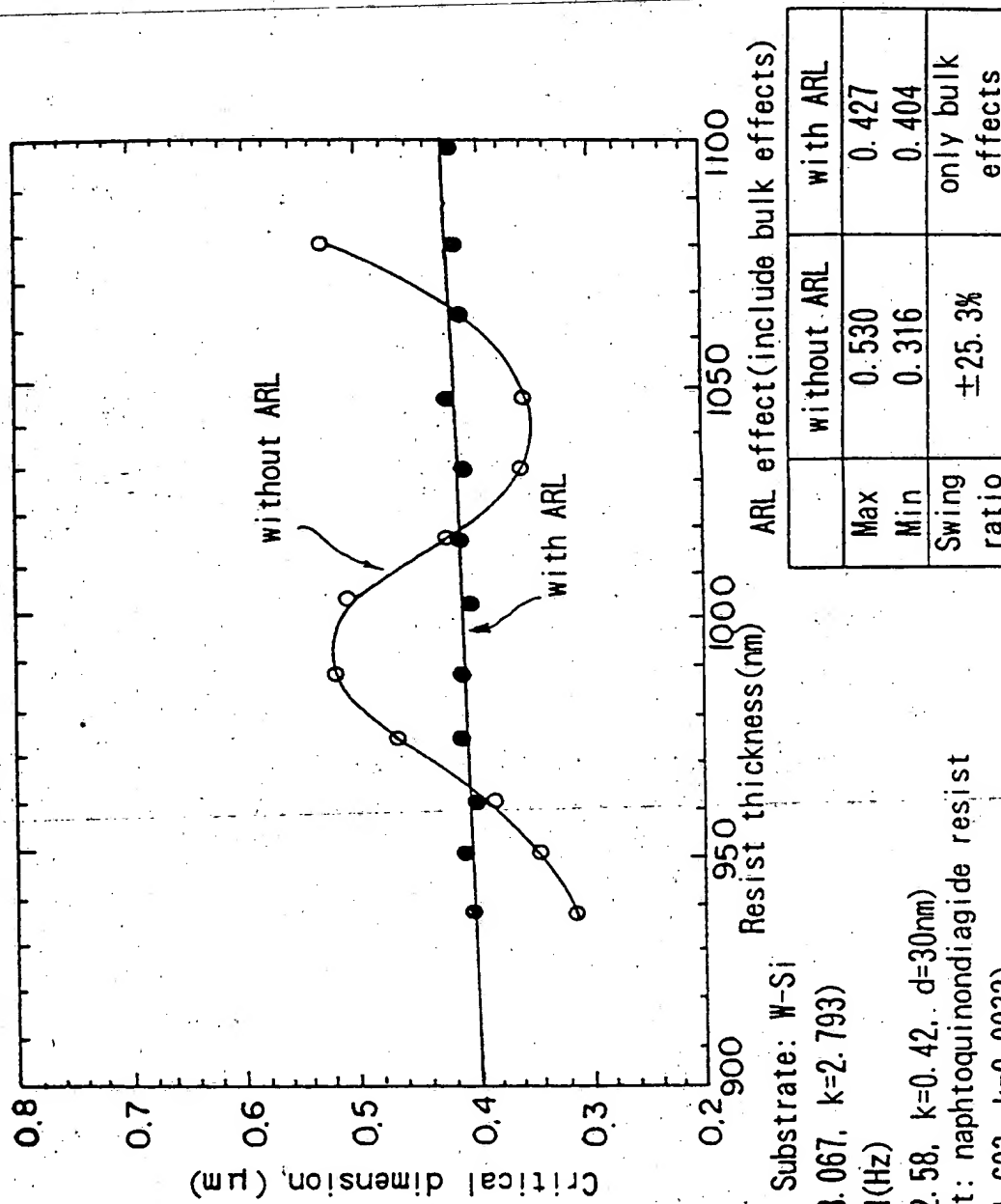
$d=30\text{nm}$

$n_{\text{pr}}=1.7$

$k_{\text{pr}}=0.00174$

# Fig.64

Anti-reflective effect of the film formed  
in Example 90 (measured m i line lithography) on W-Si, 0.44  $\mu\text{mL}/\text{S}$  ( $k_1=0.63$ )



Conditions: Substrate: W-Si

( $n=3.067$ ,  $k=2.793$ )

AR: Six0yN(Hz)

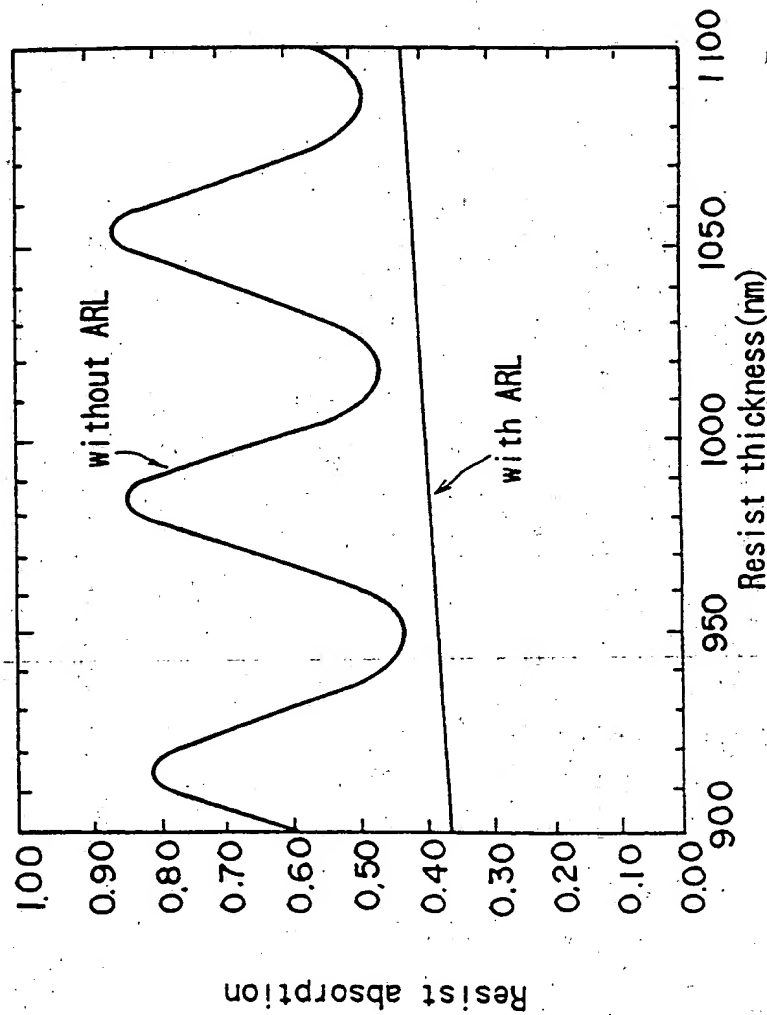
( $n=2.58$ ,  $k=0.42$ ,  $d=30\text{nm}$ )

Photoresist: naphtoquinondiagide resist

( $n=1.693$ ,  $k=0.0032$ )

# Fig.63

Anti-reflective effect of the film formed  
in Example 90 (simulation) on Al-Si



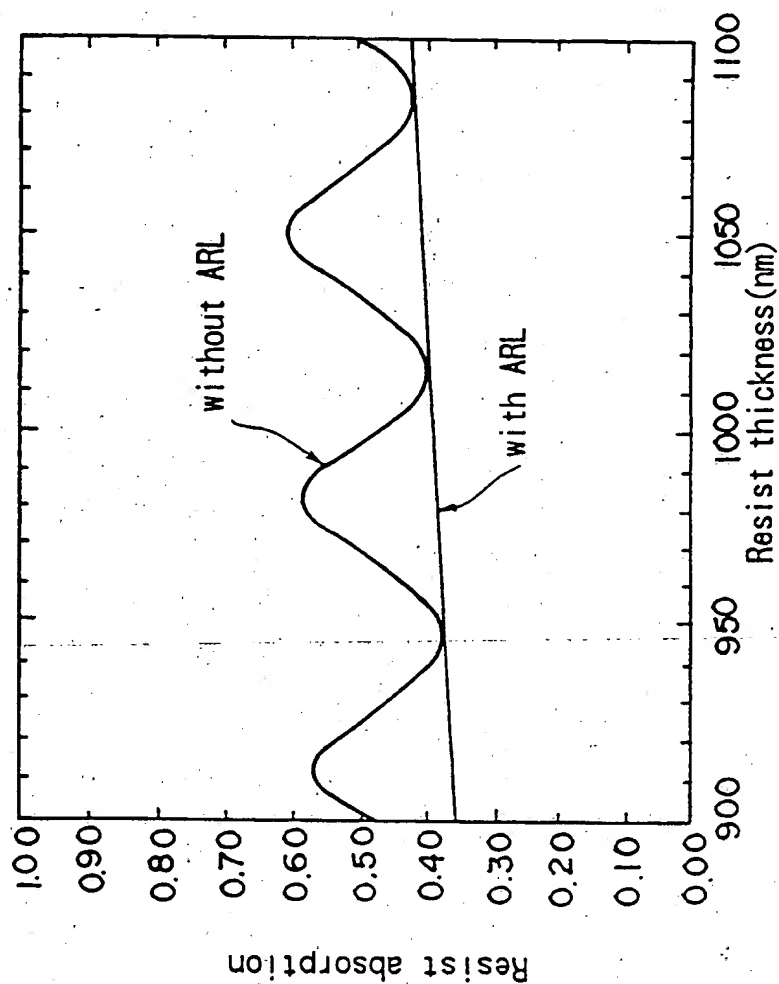
Conditions for simulation: Photoresist:  $n=1.80$ ,  $k=0.011$

$\text{SiO}_2/\text{Ny}(\text{Hz})$ :  $n=2.09$ ,  $k=0.87$ ,  $d=24\text{nm}$

Al-Si:  $n=0.089$ ,  $k=2.354$

# Fig.62

Anti-reflective effect of the film formed  
in Example 90 (simulation) on W-Si with SiO<sub>2</sub>



Conditions for simulation: Photoresist:  $n=1.80$ ,  $k=0.011$

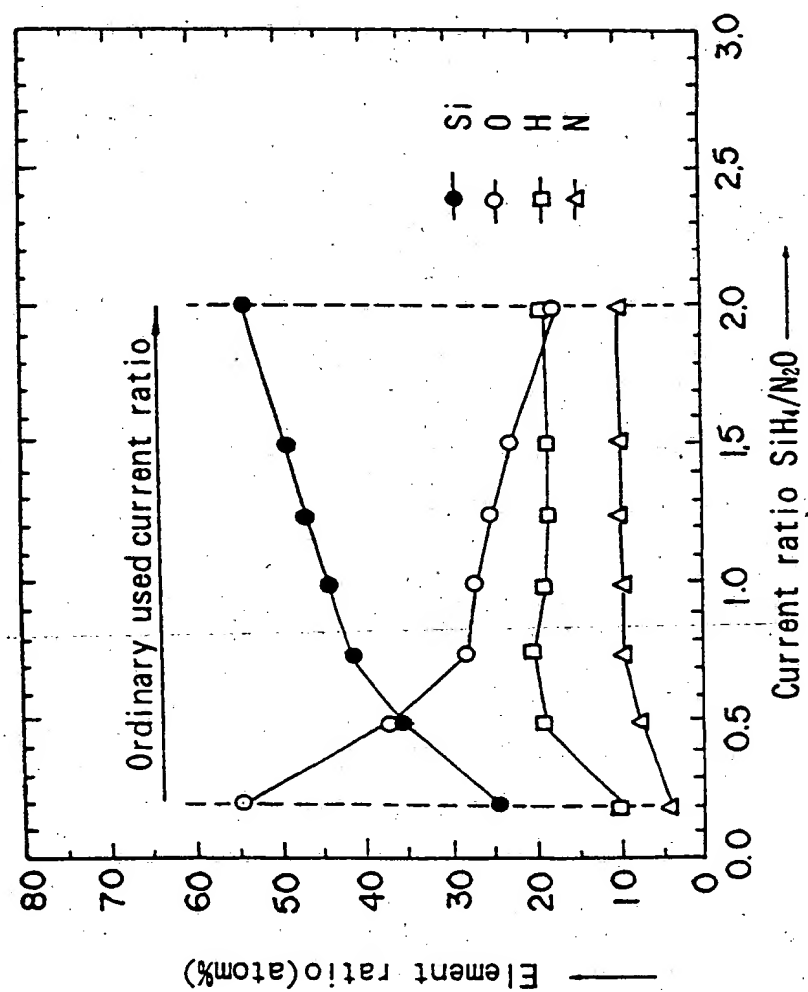
SiO<sub>2</sub>:  $n=1.52$ ,  $k=0$ ,  $d=170\text{nm}$

SiOxNy(Hz):  $n=2.12$ ,  $k=0.52$ ,  $d=29\text{nm}$

W-Si:  $n=1.93$ ,  $k=2.73$

Fig.61

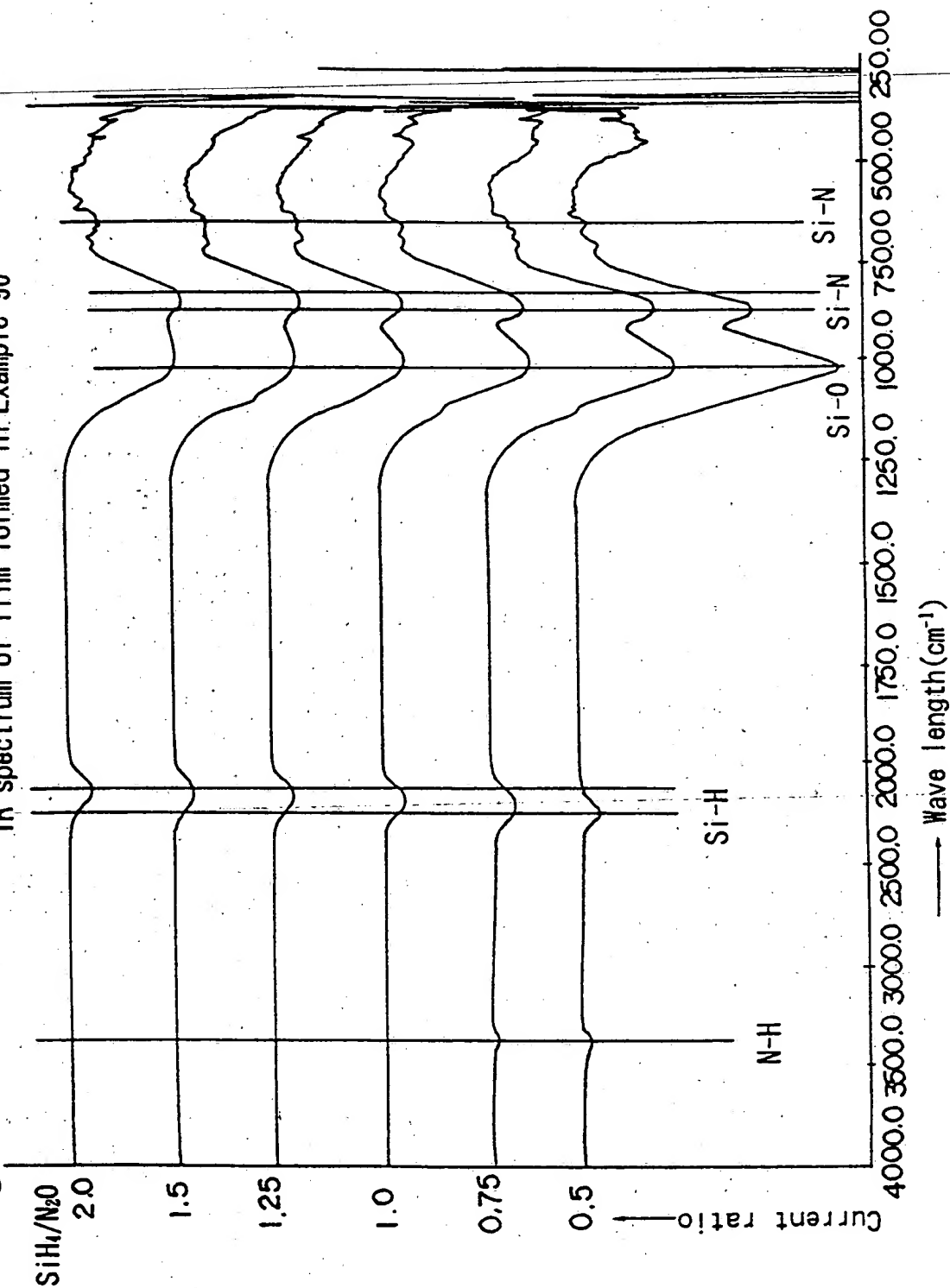
Ordinary used current ratio of SiH<sub>4</sub>/N<sub>2</sub>O for forming SiO<sub>x</sub>N<sub>y</sub> film



Film forming conditions: As same in Fig.59

Fig.60

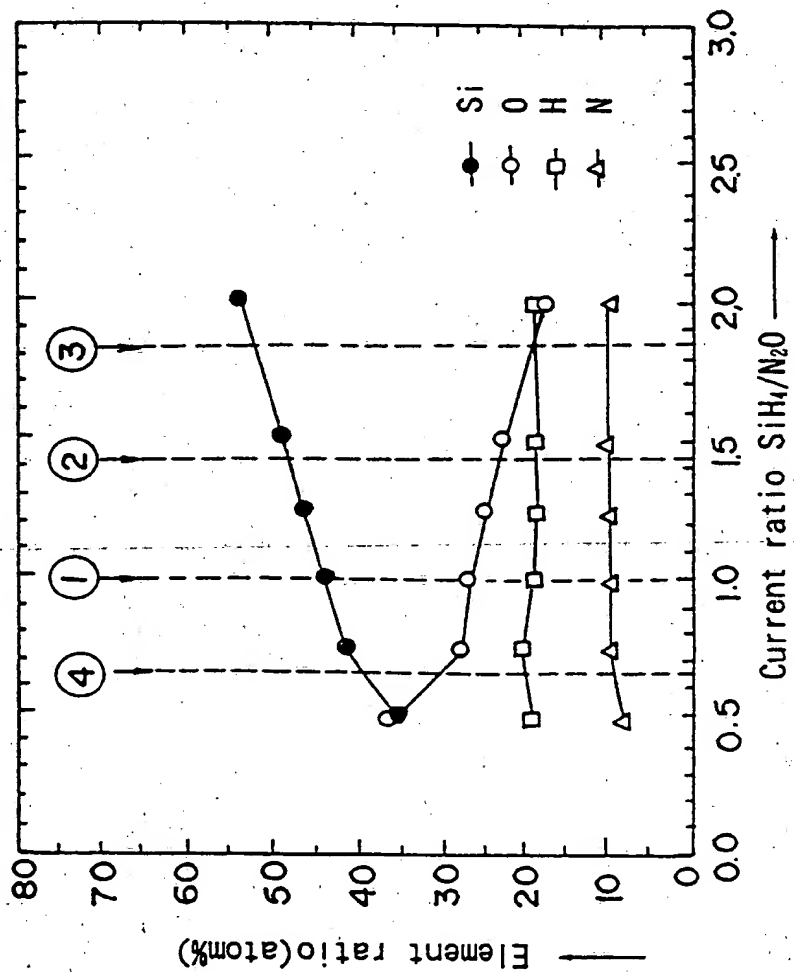
IR spectrum of film formed in Example 90



# Fig.59

Example 90

Relationship between current ratio  $\text{SiH}_4/\text{N}_2\text{O}$  and element ratio of Si, O, N, H (RBS value) of the formed film of  $\text{SiOxNy}$

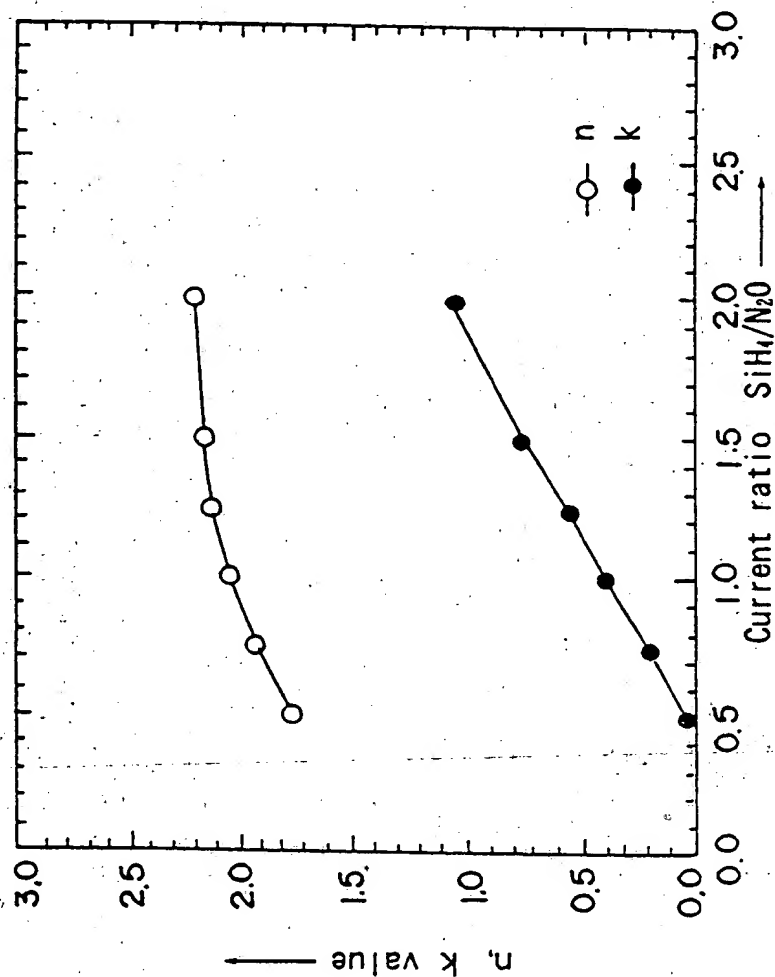


Film forming conditions: As same in Fig.58 other than the film forming time is 40 sec



# Fig.58

Example 90  
Relationship between current ratio  $\text{SiH}_4/\text{N}_2\text{O}$  and  
n, k value of the formed film of  $\text{SiO}_x\text{N}_y$



Film forming conditions:  $\text{SiH}_4 = 50\text{sccm}$

$\text{N}_2\text{O} = 25, 33, 40, 50, 67, 100\text{sccm}$

Temperature:  $360^\circ\text{C}$

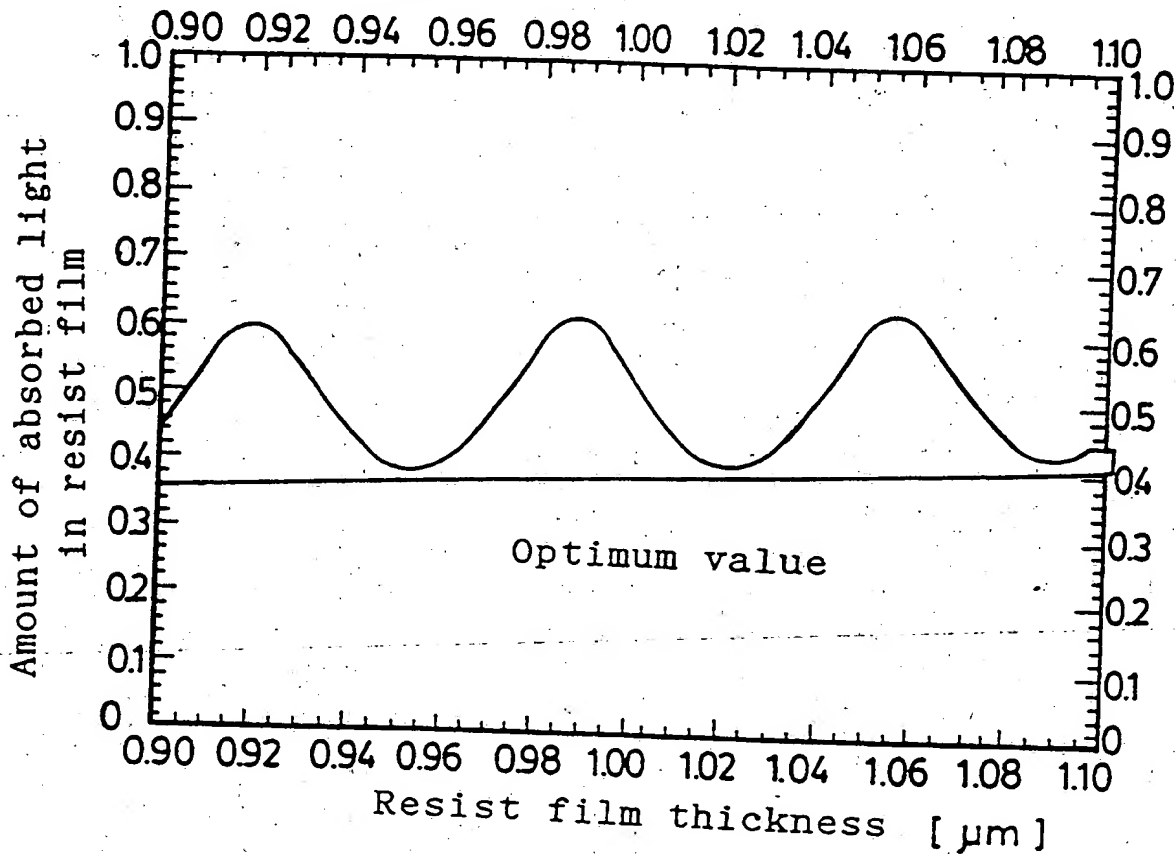
RF power:  $190\text{W}$

Pressure:  $2.5\text{Torr}$

Film forming time:  $5\text{sec}$

# Fig.57

Anti-reflective effect of  $\text{Si}_x\text{O}_y\text{N}_z$ ,  $\text{Si}_x\text{N}_y$  film (33 nm) on Poly-Si, amorphous silicon, doped polysilicon substrate



XP8843 /  $\text{Si}_x\text{O}_y\text{N}_z$ ,  $\text{Si}_x\text{N}_y$  (33nm) / Poly-Si, amorphous-Si, doped polysilicon,

$n_{\text{PR}} = 1.801$ ,  $k_{\text{PR}} = 0.0107$ ,  
 $n_{\text{arl}} = 2.01$ ,  $k_{\text{arl}} = 0.62$ ,  $d_{\text{arl}} = 3.3\text{nm}$   
 $n_{\text{poly}} = 1.71$ ,  $k_{\text{poly}} = 3.3$